CHAPTER 6 DRAINAGE CONCEPTS

This section provides a description of the following: (a) the existing drainage conditions at SR 303L; (b) the results of the Loop 303 Corridor/White Tanks Area Drainage Master Plan Update (ADMP); (c) the off-site storm water flows at the SR 303 system interchanges at I-10, Northern Parkway, and US 60; (d) the drainage impacts on the lands potentially affected by SR 303 roadway improvements; and (e) the criteria and features of the on-site roadway drainage systems at the interchanges and along the mainline.

The drainage concepts for SR 303L are based on the following considerations:

- Interception of off-site flows by a Regional Drainage Channel and Detention Basins (from Bell Road to the Gila River) along the west side of SR 303L. This channel is a component of the Loop 303 Corridor/White Tanks ADMP finalized by the FCDMC February 2005.
- Maintenance of existing flow patterns between Bell Road and Grand Avenue.
- Limiting post-development peak discharges at outfalls to pre-development levels.
- Using FCDMC criteria in designing drainage facilities for off-site flows.
- Using ADOT criteria for designing SR 303L roadway drainage facilities.
- Input from the cities of Surprise, Glendale, and Goodyear.
- Input from many of the landowners, developers, and their consultants.

6.1 EXISTING CONDITIONS

SR 303L is currently a two-lane rural highway with at-grade intersections at each mile street crossing and limited cross-drainage culverts and storm drain systems. Small culverts cross the roadway at approximately a dozen locations. The existing ditches and culverts convey runoff from the more frequent storm events but are unlikely to be adequate for the larger stormwater flows (greater than the 2-year frequency events).

The off-site watershed to the west is largely undeveloped and consists of desert, mountains, and agricultural fields. Runoff from the White Tank Mountains and adjacent desert is conveyed overland and within washes (channels). Drainage through the farm fields occurs in the furrows and along the irrigation ditches. Sheet flow in a southeasterly direction is anticipated for larger storm events. Three major flood control dams, McMicken Dam (to the northwest) and the White Tank Flood Retarding Structure (FRS) Nos. 3 and 4 (to the west), provide significant flood protection. McMicken Dam stores runoff from a 250 square mile watershed. Closer to SR 303L, a number of recent land development projects have been built in Surprise, Glendale, and Goodyear. Some developments are under construction and more are slated for construction within the next five years. The developments in Surprise and Glendale are designed with 100-year 2-hour retention facilities and the developments in Goodyear are designed with 100-year 6-hour storm retention facilities.

6.2 LOOP 303 CORRIDOR/WHITE TANKS AREA DRAINAGE MASTER PLAN UPDATE

The FCDMC recently completed updating the existing White Tanks ADMP to specifically cover the proposed Loop 303 corridor, which runs south from approximately north of Grand Avenue to the Gila River. Figure 6-1 is a pictorial description of the ADMP system within the SR 303L corridor. The purpose of this study is to:

- Identify the existing drainage issues
- Develop a plan for flood protection and associated multi-use facilities within the watershed
- Develop a plan for an outfall for the runoff – ultimately to the Gila River
- Coordinate these plans with the development of SR 303L

The study includes analysis of approximately 220 square miles of watershed from the McMicken Dam south to the Gila River and from the White Tank Mountains east to the Agua Fria River. The study identifies drainage problems, updates the existing hydrology due to development and new hydrologic methodology, develops cost-effective solutions for a storm water collection/ conveyance system, and identifies potential outfall alternatives.

History and Process

The Loop 303 Corridor/White Tanks ADMP is the culmination of a process, which began with the *White Tanks Area Drainage Master Plan* (1988-92) prepared for FCDMC. The original study proposed a north-south channel along the SR 303L corridor to the Gila River. The *Estrella Corridor Study, MC 85 to Interstate 17* (1998) prepared for MCDOT followed this study. A north-south concrete channel complemented with detention basins to reduce peak flows was recommended in this study. In 1999, FCDMC began the process of updating the area drainage master plan with the focus being on the SR 303L corridor. A wide multi-use grass-lined north-south channel with detention basins and east-west channel connections was selected as the preliminary preferred alternative. More recently, discussions among FCDMC, ADOT, and MCDOT led to the concept of jointly funding and constructing the drainage facility as part of SR 303L. A north-south concrete channel with detention basins and east-west channel connections was selected as the preferred concept.

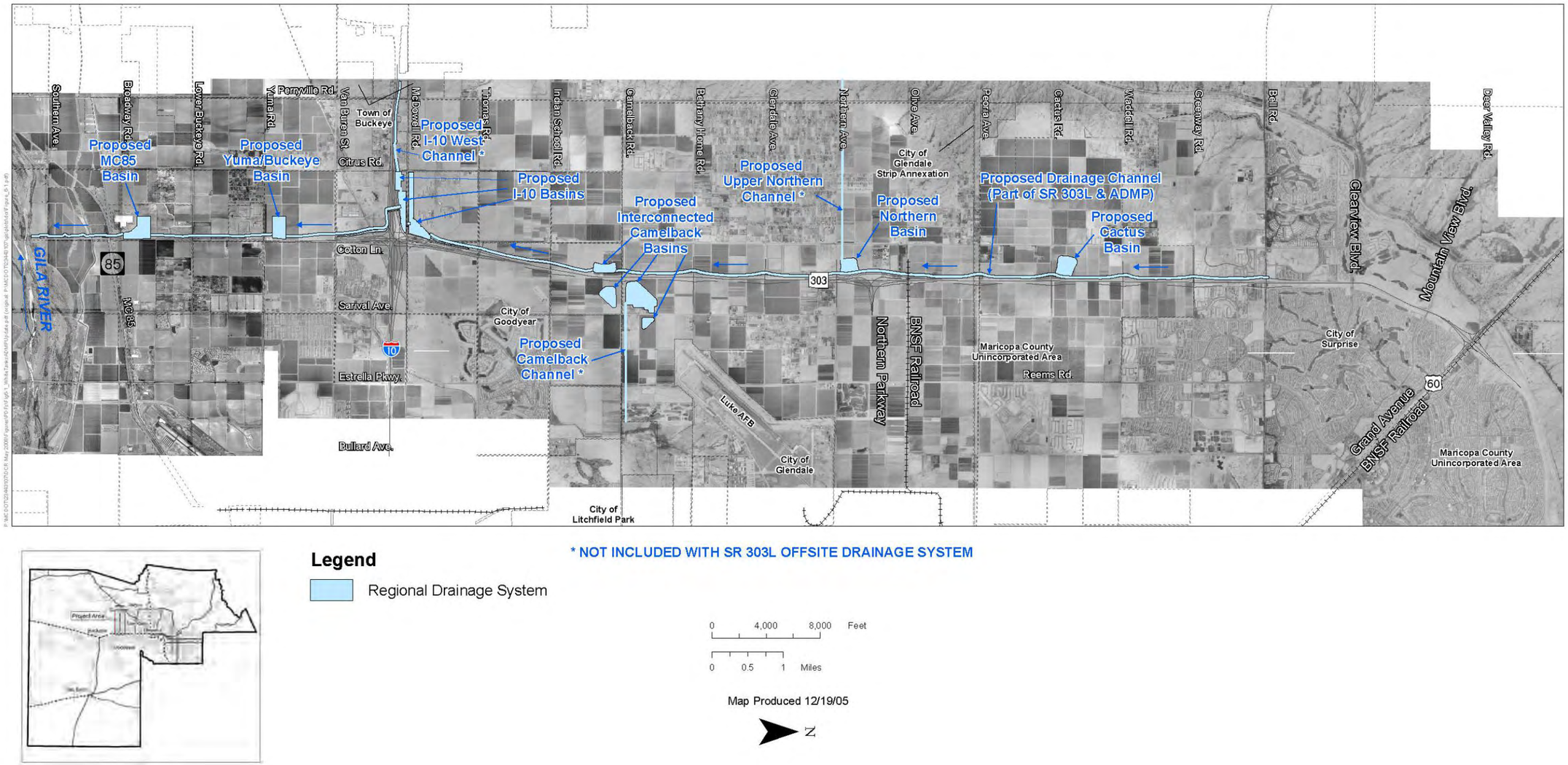


Figure 6-1 Loop 303 Corridor/White Tanks ADMP Update Along SR 303L

Design Criteria

Design criteria by the FCDMC are based on recognition of predicted flows with existing rural conditions as well as predicted flows with future urban conditions within the watershed. Significant design criteria for the regional drainage channel and associated detention basins along the west side of SR 303L include:

- Depth of channel based on 100-year water surface with existing conditions without freeboard and 100-year water surface with future conditions plus freeboard. Minimum freeboard for supercritical flow conditions (the prevalent condition along the channel) is 2 feet; subcritical flow regime requires a minimum freeboard of 1 foot.
- Depth of detention basin based on 100-year water surface with existing conditions without freeboard and 100-year water surface with future conditions plus 1 foot of freeboard.
- Bleedoff facility (pipe) to drain the detention basins within 36 hours.
- Maintenance Road (20 feet wide) on west side of the channel and along the perimeter of detention basins.
- Buffer area for landscaping and aesthetics (30% of detention basin footprint) along the perimeter of the detention basin.
- 10-foot buffer along the west side of the 20-foot access road adjacent to SR 303L.
- Detention basin side slopes to be 6 (horizontal): 1 (vertical)
- Regional concrete lined channel side slopes to be 2 (horizontal): 1 (vertical)

Major Off-site Drainage Features (related to SR 303L only)

The major off-site drainage facilities developed as part of the Loop 303/White Tanks ADMP that would be incorporated into the highway plans are shown in Figure 6-2 and include:

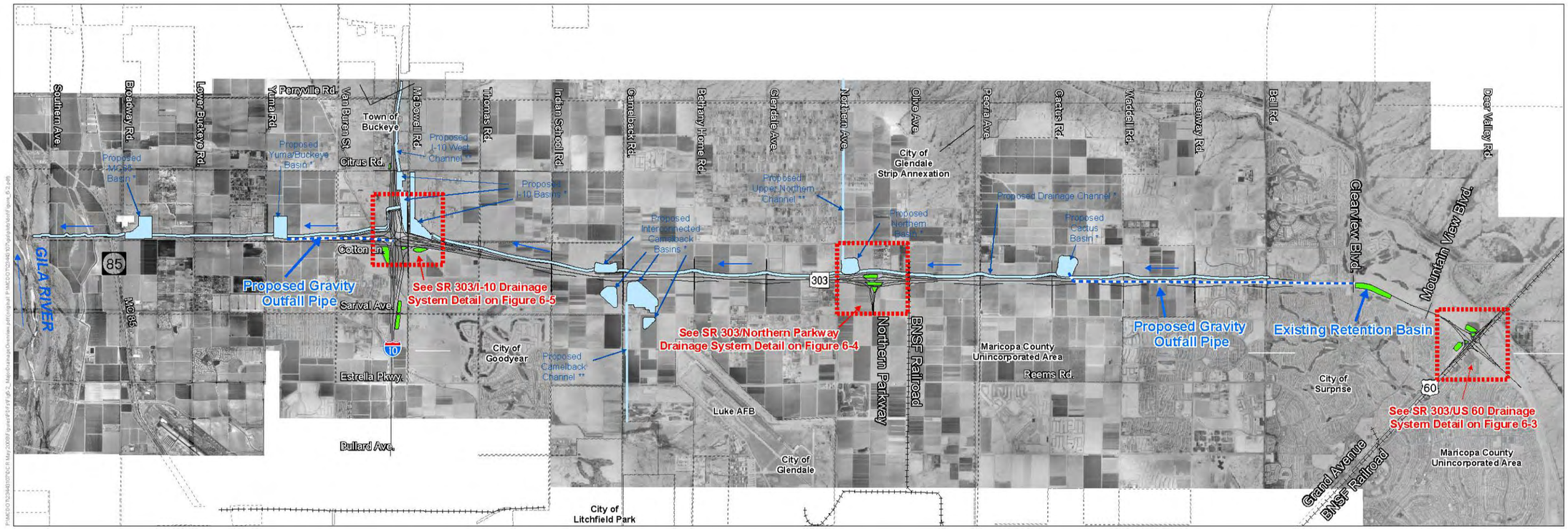
- A north-south regional drainage channel along the west side of SR 303L from Bell Road to the Gila River. The channel is planned to eliminate breakouts at approximately 15 separate locations along the existing SR 303L alignment. It will serve to alleviate existing flooding downstream as well as provide an ultimate outfall to the Gila River for the entire ADMP Project area west of SR 303L.
- Off-line detention basins at the northwest corners of Cactus Road/SR 303L and Northern Avenue/SR 303L. The Northern Avenue basin would also serve as an outfall for the proposed Northern Avenue Channel from the west that would not be part of the highway drainage system.
- Multiple (4) interconnected on-line detention basins at the Luke AFB crash zone site near Camelback Road. Basins would be relatively shallow with approximately 6-foot ponding depth; bleedoff facilities (pipes) would be provided south and east of these basins.
- Multiple (2) interconnected on-line detention basins northwest of I-10/SR 303L interchange. The northern basin would be north of McDowell Road and located within and adjacent to the existing Perryville Prison property limits along its south and east perimeter; the southern basin would be south of McDowell Road and east of the proposed interchange; the south basin also would serve as an outfall for the proposed I-10 tributary from the west along the north side of I-10. An outfall conduit would cross I-10, connect south to an open channel that would discharge into the Gila River.
- Single online detention basins at the northwest corners of Buckeye Road/SR 303L and MC 85/SR 303L would meter flows into the proposed SR 303L channel, thereby reducing the size of the proposed downstream SR 303L channel. The MC 85 basin would allow for a smaller structure crossing the MC 85 roadway and the Union Pacific Railroad.

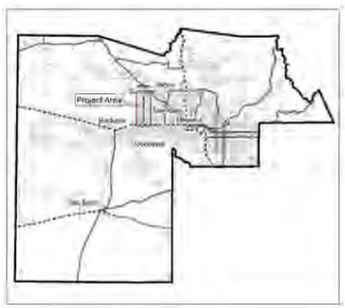
Potential Stand-Alone Segments

To provide information needed in the future programming and phased construction of the roadway and drainage system, the overall drainage system was reviewed to identify logical break points. It is usually advantageous from drainage considerations to construct the SR 303L regional drainage system from the downstream end to the upstream end—south to north in this case. However, programming concerns may require the roadway to be built from north to south. A desirable two-phase/segment construction sequence from a drainage perspective that can be investigated is:

- US 60 Interchange to Camelback Road
- Camelback Road to the Gila River

The termini for the first segment, i.e., US 60 interchange to Camelback Road, would be the system of interconnected detention basins at the Luke AFB crash zone site at Camelback Road.





Legend

- Regional Drainage System
- Roadway Detention Basin
- Major Storm Drain/Gravity Outfall Pipe

* PART OF LOOP 303 CORRIDOR/WHITE TANKS ADMP UPDATE INCLUDED WITH SR 303L OFFSITE DRAINAGE SYSTEM

** PART OF LOOP 303 CORRIDOR/WHITE TANKS ADMP UPDATE NOT INCLUDED WITH SR 303L OFFSITE DRAINAGE SYSTEM

0 4,000 8,000 Feet

0 0.5 1 Miles

Map Produced 12/19/05

N

Figure 6-2 SR 303L Major Drainage Systems - An Overview

In case roadway programming requires a further segmentation, the following sub-segments with their termini at regional detention basins can be investigated:

- US 60 Interchange
- US 60 to Bell Road
- Bell Road to Cactus Road
- Cactus Road to Northern Avenue
- Northern Avenue to Camelback Road
- Camelback Road to I-10
- I-10 to Gila River

The drainage considerations in implementation of these segments would be to:

- Evaluate existing conditions of flow at the downstream (south) end of these segments
- Simulate existing conditions of flow at these outlets by a variety of measures which may include expanding the current design of detention basins and providing spreader basins, energy dissipaters, and weir flow; these spreader basins may be a few hundred or thousands of feet in length.

6.3 OFF-SITE DRAINAGE AT SYSTEM INTERCHANGES

The three system interchanges are each unique in its configuration, placement within the watershed, and drainage features. Figure 6-2 is a pictorial description of the major drainage systems for SR 303L. Off-site drainage features at the interchanges are described below.

Off-site Drainage at the SR 303L/I-10 Interchange

Off-site flows would be intercepted by the regional drainage channel along the west side of the SR 303L southbound frontage road and by the detention basins north and south of McDowell Road. Figure 6-3 is a pictorial description of the SR 303L/I-10 Interchange drainage system.

Off-site Drainage at SR 303L/Northern Parkway Interchange

The regional drainage channel along the west side of the SR 303L southbound frontage road would intercept off-site runoffs. Figure 6-4 is a pictorial description of the SR 303L/Northern Parkway Interchange drainage system.

Off-site Drainage at SR 303L/US 60 Interchange

Since the intersection of SR 303L and US 60 occur where the two roadways are at 45 degrees from the cardinal directions, a different nomenclature was used for discussion to identify the quadrants. The quadrants fall in the cardinal directions so that the quadrant bounded by the west leg of US 60 and the north leg of SR 303L is the north quadrant.

The off-site flows in the interchange area are from the undeveloped tracts of land in the west and north quadrants of the US 60/SR 303L interchange. Figure 6-5 is a pictorial description of the SR 303L/US 60 Interchange drainage system.

A retention basin would be provided to prevent flows in the west quadrant from coming onto the depressed interchange ramps. An outlet pipe with a control gate would meter the flow into an infield detention basin.

Flows from the north quadrant would be diverted along the east side of SR 303L and then intercepted by a relocated culvert so the water can pass under SR 303L. An outlet ditch would be provided to bring the flows back to the natural outfall and maintain the existing pattern of flow to the southeast.

6.4 LANDS POTENTIALLY AFFECTED BY ROADWAY IMPROVEMENTS

The SR 303L roadway and associated drainage improvements, especially the regional channel and associated detention basins, are likely to benefit the:

- Lands to the west of SR 303L by providing a positive outfall to the south
- Lands to the east of SR 303L by reducing or eliminating off-site flows

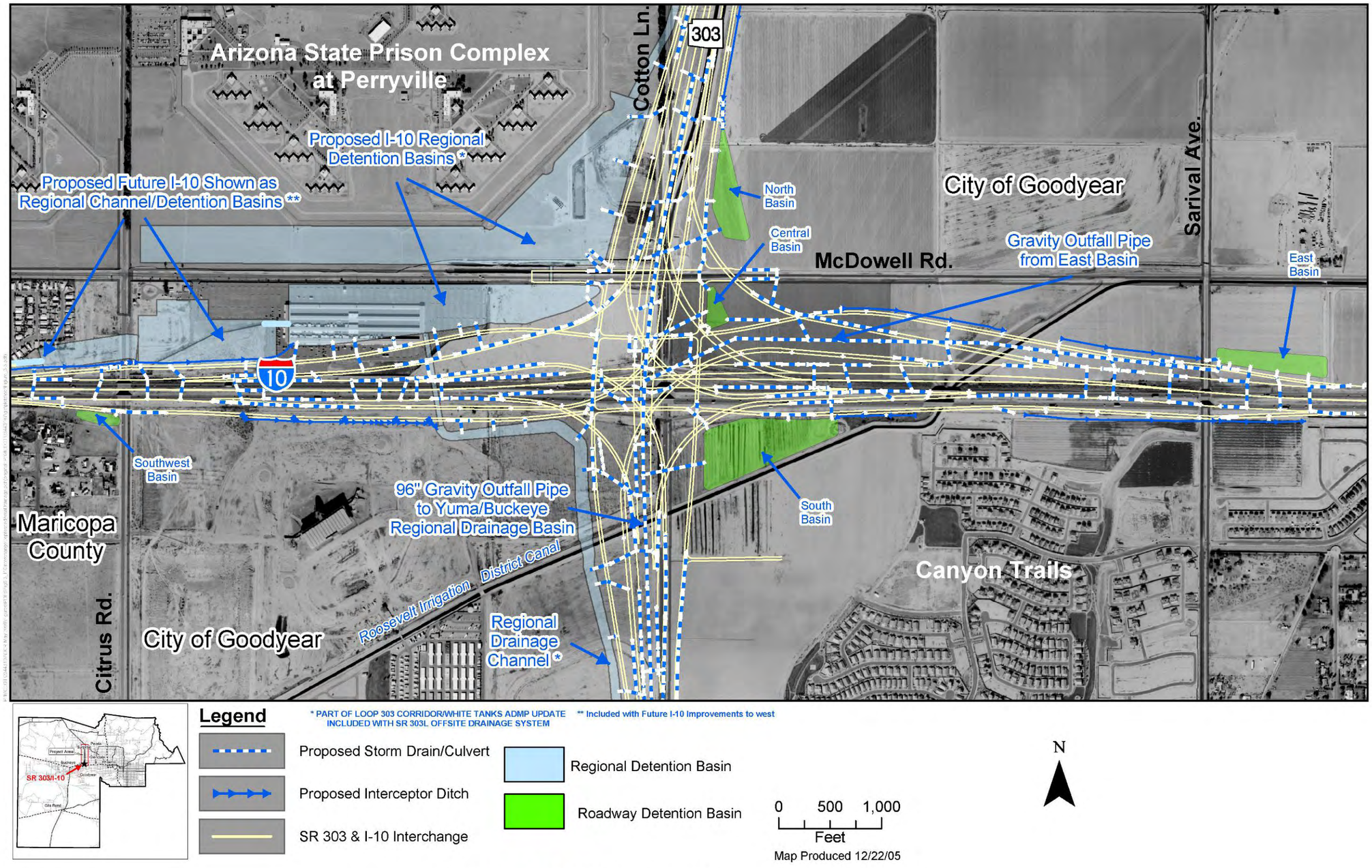


Figure 6-3 SR 303L/I-10 Interchange Depressed Area Drainage System

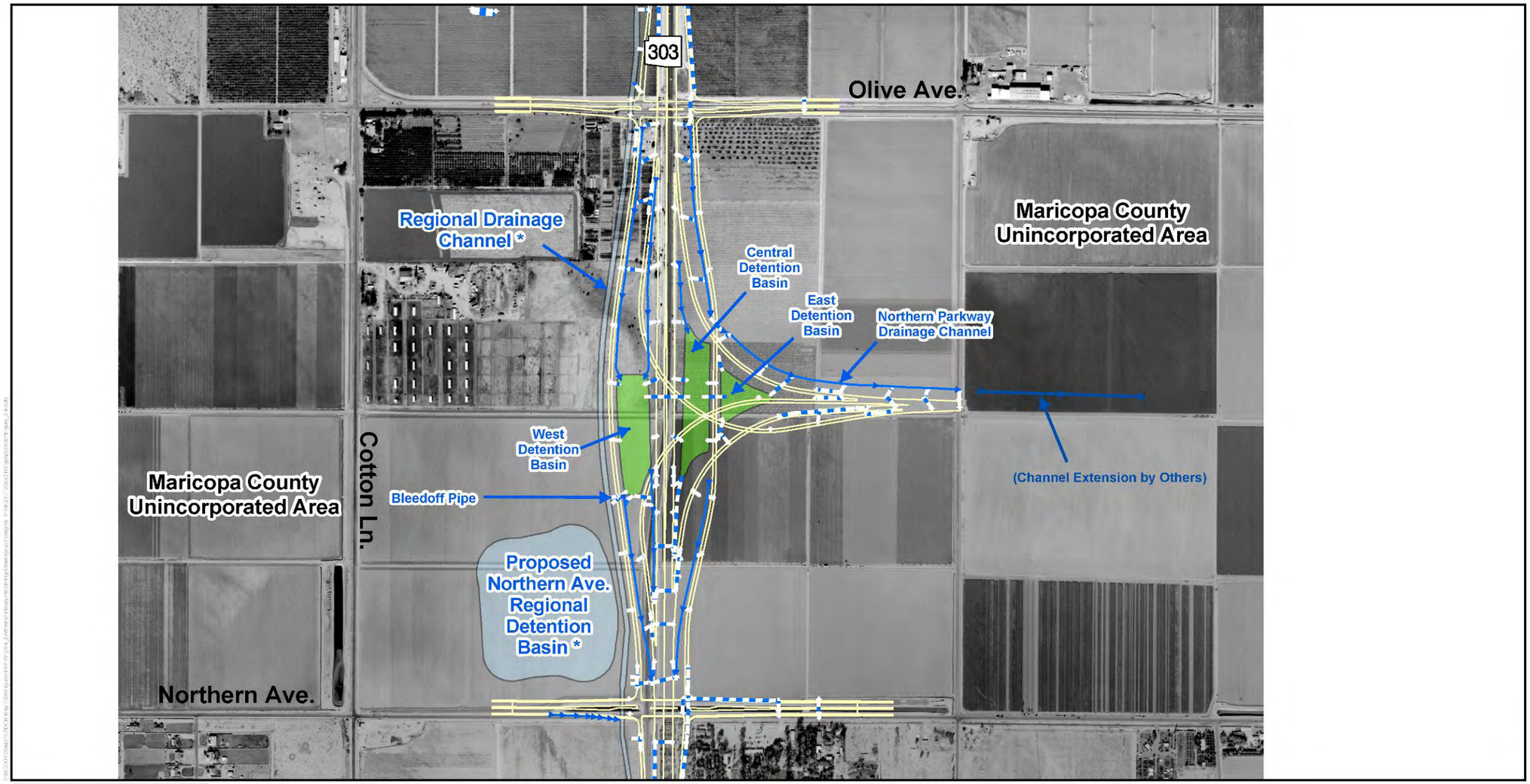
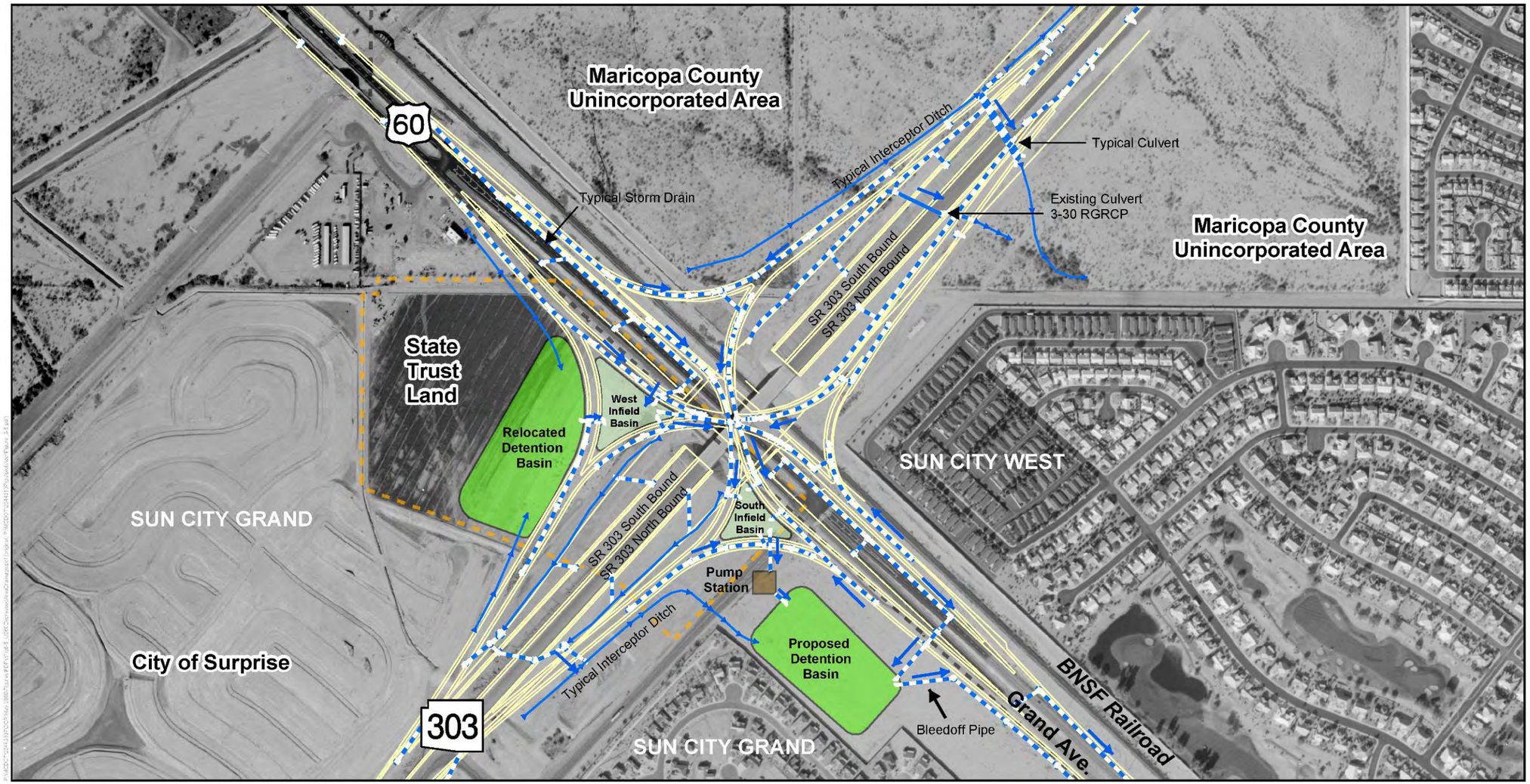
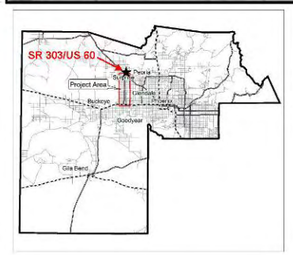


Figure 6-4 SR 303L/Northern Parkway Interchange Drainage System





Legend

- Proposed Storm Drain/Culvert
- Proposed Interceptor Ditch
- SR 303 & US 60 Interchange
- Infield Basin
- Detention Basin
- Pump Station

0 250 500
Feet

Map Produced 12/22/05

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Figure 6-5 SR 303L/US 60 Interchange Depressed Area Drainage System

6.5 ON-SITE ROADWAY DRAINAGE

This section outlines the design procedures and methodology used in the hydraulic design of the proposed on-site or pavement drainage systems for the ultimate freeway improvements along the SR 303L corridor.

Criteria and Standards

ADOT criteria have been used for designing roadway drainage facilities. Drainage criteria adopted by MCDOT and the cities of Surprise, Glendale, and Goodyear have been considered in the design of the crossing arterial and minor arterial streets.

Hydrologic Analysis

Rational method was used for computing the peak runoff rate (discharge). These peak discharges were used to estimate the runoff spread, locate/design catch basins, size storm drain systems, ditches and culverts. The detention basins and pumps associated with the interchange drainage systems were analyzed with U.S. Army Corps of Engineers' (ACOE) HEC-1 hydrograph based computer program.

Design storm events are:

- 10-year for non-depressed roadways
- 50-year for depressed roadway

Rational method parameters are:

- Minimum time of concentration: 10 minutes
- Rainfall intensity: based on procedures within the ADOT Hydrology Manual
- Runoff coefficients: paved surface: 0.95
  highway slopes: 0.70

Inlet/Catch Basin Spacing Design

Catch basin spacing was based on several criteria. First, catch basins are located at all sag locations on pavement. Second, catch basins are placed at the beginning of transitions to pavement rollover. Third, catch basins are located at intersections and gore areas. Once these catch basins have been located for a particular section of pavement, intermediate catch basins are located using depth and spread design criteria. Fourth, catch basins are located in the medians and interchanges to pick up infield area drainage.

More specifically, the maximum spread of runoff due to a 10-year storm event in non-depressed and non-sag areas is the smaller of the following values:

- Spread when the runoff depth reaches height of curb
- Spread over shoulder and half the traffic lane in case of SR 303 mainline pavement and a two-traffic-lane wide ramp
- Spread over shoulder in case of a one-traffic-lane wide ramp

Spread of runoff over a city street crossing SR 303 is such that there is no curb overtopping and at least one 12-foot traffic lane in each direction would remain dry.

At sag or depressed locations (below adjacent existing ground) the 50-year storm event was used to compute the runoff spread across the pavement. The allowable maximum spread shall be the width of the shoulder plus one full traffic lane for a roadway with two or more traffic lanes.

It may be noted that the runoff spread is dependent on the height of the curb. In this regard, the 6-inch high curb (ADOT Std. C-05.10-B) was used for SR 303L and entrance/exit ramps when:

- Roadway pavement is below cut areas
- SR 303L roadway pavement is below adjacent ramp
- Ramp pavement is below adjacent SR 303L roadway

The 3-inch high curb (ADOT Std. C-05.10-C) is used on SR 303 and entrance/exit ramps when:

- Roadway pavement is in fill areas
- Roadway pavement is above adjacent drainage channel or detention basin

The 6-inch high curb (MAG Std. 220) is used along US 60 (Grand Avenue) and City streets crossing SR 303L.

Storm Drain System Design

The storm drain system is designed to minimize the length of pipes by directly draining to the regional drainage channel, ditches, or adjacent detention basins. However, storm drain trunk lines are provided within depressed areas to provide a gravity outlet to the regional drainage channel. The following criteria are followed in design of the storm drain system:

- Hydraulic Grade Lines: Six inches below the top of grate/inlet elevation. In case of a segment of depressed roadway use a 50-year frequency storm event. In non-depressed areas a 10-year storm event is selected for design.
- Catch Basins/Inlets: ADOT C-15.30 catch basins are used for roadways. ADOT C-15.80 inlets are used for median and area drains. Slotted drains connected to catch basins are recommended at all sag locations. At this level of design effort, a 10-foot length of slotted drain is considered with each catch basin.
- Manholes: Desirable maximum manhole spacing is:
  - 330 feet for 30-inch and smaller storm drains
  - 500 feet for 36-inch storm drains
  - 660 feet for 42-inch to 66-inch storm drains
  - 1,200 feet for 72-inch and greater storm drains
- Storm Drains:
  - Minimum pipe size: 24 inches
  - Minimum velocity: 2 feet per second flowing full
  - Preferable minimum velocity: 3 feet per second flowing full
- Storm Drain Outlets: Storm drains with outlets to channels conform to ADOT C-13.75.

The size of the main storm drain trunklines ranges from 24 inches to 72 inches. Lateral pipes are 24 inches in diameter. Lateral pipes are connected to manholes at approximately 90 degrees.

SR 303L/I-10 Interchange Drainage System

The proposed SR 303L/I-10 interchange consists of the (a) SR 303 and I-10 mainline roadways, (b) interchange ramps, (c) northbound and southbound frontage roads (from Thomas Street south to Van Buren Street), and (d) eastbound and westbound frontage roads (from Citrus Road east to Sarival Avenue).

A pictorial description of the SR 303L/I-10 Interchange drainage system is shown in Figure 6-3. The SR 303/I-10 interchange would consist of a depressed section that includes the central portion of SR 303 and ramps, an at existing grade level that includes portions of SR 303 and frontage roads, and three above grade levels that includes I-10 and the remaining interchange ramps.

The above grade portion of the SR 303/I-10 interchange would be drained by storm drains into the regional channel west of SR 303 or into detention/retention basins prior to release within the existing or planned drainage channels/ditches. A discussion on two outfall alternatives to drain the detention basins follows.

Description of Alternatives

Several depressed area drainage alternatives were identified for a preliminary investigation. Two alternatives were determined feasible after the initial investigation. The two depressed area drainage alternatives are described below.

Alternative 1: Pump Station with Large Underground Storage Pipes

This drainage alternative requires 96-inch underground pipes (approximate length of 2,000 feet) for storage and four 25 cfs pumps to drain the interchange depressed area.

Alternative 2: Gravity Outfall into the Yuma/Buckeye Regional Detention Basin

This drainage alternative requires the installation of approximately 8,400 linear feet of 96-inch RCP to gravity drain the depressed interchange area. This large diameter pipe daylights into the Yuma/Buckeye Regional Detention Basin.

Technical Evaluation of Drainage Alternatives

The rational method was used to determine the amount of runoff flowing into the depressed area. A minimum time of concentration of 10 minutes was used for each basin. The calculations resulted in a peak flow of 290 cfs and a time to peak of 14.4 minutes for the 50-year storm event. Total estimated volume of runoff generated was 5.8 ac-ft.

Cost Analysis of Alternatives

A cost analysis was prepared for the two depressed area drainage alternatives. A brief summary of the costs is provided below:

Alt. 1: Pump Station with Large Underground Storage Pipes	$4.4 million
Alt. 2: Gravity Outfall into the Yuma/Buckeye Regional Detention Basin	$5.2 million

Evaluation of Drainage Outfall Alternatives and Recommendation

Alternative 1, Pump Station with Large Underground Storage Pipes, is the less expensive depressed area drainage alternative; however, additional operational and maintenance costs are likely to be incurred over the long term.

Alternative 2, Gravity Outfall into the Yuma/Buckeye Regional Detention Basin, is the more expensive alternative; however, the upfront higher costs are likely to be offset by lower operation and maintenance costs.

The long-term operational and maintenance benefits lead us to recommend Alternative 2: Gravity Outfall into the Yuma/Buckeye Regional Detention Basin.

SR 303L/Northern Parkway Interchange Drainage System

The proposed Northern Parkway system of ramps, frontage roads and SR 303L roadway is drained by storm drains into detention basins prior to release into the regional drainage channel along the west side of the roadway or into a proposed channel along the north side of Northern Parkway – east of SR 303L. A pictorial description of the SR 303L/Northern Parkway interchange drainage system is shown in Figure 6-4.

SR 303L/US 60 Traffic Interchange Drainage System

The proposed SR 303L/Grand Avenue traffic interchange (TI) consists of (a) Grand Avenue and BNSF at existing grade, (b) SR 303L mainline roadway over Grand Avenue and BNSF, and (c) SR 303L ramps under Grand Avenue and BNSF. The above situation creates a depressed area approximately 30 feet below Grand Avenue for the four intersecting ramps. A pictorial description of the SR 303L/US 60 Interchange drainage system is shown in Figure 6-5.

A number of depressed area drainage alternatives were identified for a preliminary investigation. After the initial investigation, a pared down list of the following alternatives was subjected to a more rigorous technical and cost analysis. A brief description of the alternatives is provided below:

Alternative 1: Deep Infield Basins and Gravity Outfall Pipe

The most significant feature of this drainage alternative is the elimination of pumps to drain the interchange depressed-area. The main elements of this drainage alternative are (a) two deep infield basins between ramps, and (b) a 24-inch gravity outfall pipe (7,600 feet long) from the interchange to a ditch between Grand Avenue and the BNSF.

An iterative hydrologic/hydraulic analysis led to the design of a combination of sized infield detention basins and the 24-inch gravity outfall pipe. The 24-inch pipe would discharge approximately 11 cfs.

Alternative 2: Deep Infield Basins, Small Pump and Outfield Detention Basin with Bleedoff Pipe

This drainage alternative requires infield basins for storage and pumps to drain the interchange depressed-area. The main elements of this drainage alternative are (a) two deep infield basins for detention storage, (b) an 11 cfs pump with a backup to drain the infield basins to the outfield detention basin, (c) an outfield detention basin (4H:1V side slopes and water depth of 3 feet) with 6 ac-ft storage volume for a 50-year 24-hour storm event, and (d) a bleedoff pipe (approximately 1,300 feet long) from the outfield detention basin to a ditch along the south side of Grand Avenue.

Alternative 3: Large Underground Storage Pipes, Medium Pump and Outfield Detention Basin with Bleedoff Pipe

This drainage alternative requires 96-inch underground pipes (2,500 feet long) for storage, two 25 cfs pumps to drain the interchange depressed area and an outfield detention basin (4H:1V side slopes and water depth of 3 feet) with 6 ac-ft storage volume for a 50-year 24-hour storm event.

A HEC-1 model was developed for evaluating this alternative. The HEC-1 model indicates that the combination of the large underground storage pipes and the 25 cfs pump would result in a discharge of approximately 25 cfs by the pump to the outfield detention basin. The bleedoff pipe would discharge approximately 11 cfs into the ditch along the south side of Grand Avenue.

Technical Evaluation of Drainage Alternatives

Technical evaluation of the depressed area drainage alternatives required completion of a few preliminary tasks. A drainage system was laid out that minimized the amount of runoff to the interchange depressed area location. Drainage areas were delineated on the basis of the preliminary drainage system layout. The HEC-1 run resulted in a peak flow of 112 cfs for the 50-year 24-hour storm event. Total volume of runoff generated as 6 ac-ft. The goal was to reduce peak flow by providing storage within detention basins or large underground pipes and thereby reduce the size of the pump or gravity outfall pipe.

Cost Analysis of Alternatives

A cost analysis was prepared for the final three depressed area drainage alternatives. A brief summary of the costs is provided below:

Alt. 1:	Deep Infield Basins and Gravity Outfall Pipe	$4.0 million
Alt. 2:	Deep Infield Basins, Small Pump and Outfield Detention Basin with Bleedoff Pipe	$1.7 million
Alt. 3:	Large Underground Storage Pipes, Medium Pump and Outfield Detention Basin with Bleedoff Pipe	$3.1 million

Evaluation of Drainage Alternatives and Recommendation

Alternative 1, Deep Infield and Gravity Outfall Pipe, is the most expensive depressed area drainage alternative; however, it is considered the most feasible gravity outfall drainage solution. The advantage is elimination of pumps and associated operation and maintenance costs.

Alternative 2, Deep Infield Basins, Small Pump and Outfield Detention Basin with Bleedoff Pipe, is the least costly depressed area drainage solution. It relies on deep infield detention basins for storage and a relatively small pump to drain the discharge.

Alternative 3, Large Underground Storage Pipes, Median Pump and Outfield Detention Basin with Bleedoff Pipe, is the second most expensive solution due to the provision of large underground 96-inch RCP pipes.

The significant differences in costs leads us to recommend Alternative 2: Deep Infield Basins, Small Pump and Outfield Detention Basin with Bleedoff Pipe.

SR 303 Mainline Ultimate and Initial Construction

The mainline ultimate construction consists of the following significant drainage features:

- Storm drain systems along SR 303L roadway and ramps discharging into the regional drainage channel or detention basins (along the west side of SR 303L).
- Storm drain systems along SR 303L and between Mountain View Boulevard and Bell Road initially discharge into adjacent large detention basins and ultimately via a large storm drain trunk line into the regional detention basin at Cactus Road. It may be noted that this basin will need to be converted into an on-line basin due to this storm drain trunk line.

The mainline initial construction consists of a median ditch with inlets along the (a) proposed storm drain trunk line or (b) the proposed cross storm drain line discharging into the regional channel along the west side of SR 303L.